IN THE ABSTRACT:

Please cancel the current abstract and insert the following. A marked-up copy showing the changes made to the abstract is attached hereto in Appendix A.

-- An illumination system for illuminating a surface by use of light from a light source. The system includes an emission angle conserving optical unit having one of a lens and a lens array, for receiving light from the light source, and a diffractive optical element for diffracting light from the emission angle conserving optical unit to produce a desired light intensity distribution on a predetermined plane. The diffractive optical element is disposed one of (i) at or adjacent to a position where the light from the emission angle conserving optical unit is focused by the one of the lens and the lens array, and (ii) at a position which is optically conjugate with a position at which the light is focused by the one of the lens and the lens array. --

IN THE SPECIFICATION:

Please amend the specification as follows:

Please substitute the paragraph beginning at page 1, line 4, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- This invention relates to an illumination system and, more particularly, to an illumination system suitably usable in an illumination optical system of an exposure apparatus for the manufacture of semiconductor devices, which uses as a light source an excimer laser of a vacuum ultraviolet wavelength region. --

Please substitute the paragraph beginning at page 1, line 18, and ending on page 2, line 6, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- As regards the exposure method used in the exposure process, there is a method in which a mask surface is held in contact with or in close proximity to a wafer surface and, in this stage, the mask surface is illuminated so that the pattern of the mask is transferred to the wafer surface. Also, there is a method in which a mask (reticle) placed at a position optically conjugate with a wafer surface is illuminated, and a pattern formed on the mask surface is transferred onto a wafer surface, by projection exposure, through a projection optical system. In any exposure method, the image quality of a pattern transferred to a wafer surface is largely influenced by the performance of the illumination system, for example, the uniformness of an illuminance distribution on the surface to be illuminated. --

Please substitute the paragraph beginning at page 2, line 19, and ending on page 3, line 9, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- The divergent laser light having a divergent angle passes through the inside of the optical pipe 103 while being reflected thereby, and a plurality of apparent light source images of the laser light source 101 are produced on a plane (e.g., plane 110) perpendicular to the optical axis. Here, the laser beams, which appear as if they are emitted from the apparent light source images, are superposed one upon another on the light exit surface 103′ of the optical pipe 103,

such that a surface light source of uniform illuminance is produced at the light exit surface 103′. The light beam from the light exit surface 103′ is directed by way of a condenser lens 104, an aperture stop 105 and a field lens 106, to the reticle 107 surface. Since the light exit surface 103′ of the optical pipe 103 is in an optically conjugate relation with the reticle 107 surface, the reticle 107 surface is also illuminated uniformly. --

Please substitute the paragraph beginning at page 3, line 10, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- If the shape of the optical pipe 103 is determined while taking into account the length and width of the optical pipe 103 and the divergent angle of the laser light provided by the collimator lens 102, the optical path differences of each laser beam emitted from the apparent light sources at the plane 110 toward each of the points on the reticle 107 surface can be more than the coherence length of the laser light. This reduces the coherence with respect to time, and prevents speckle on the reticle 107 surface. --

Please substitute the paragraph beginning at page 4, line 22, and ending on page 5, line 6, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- In accordance with an aspect of the present invention, there is provided an illumination system for illuminating a surface by use of light from a light source, said illumination system comprising: an emission angle conserving optical unit effective to emit the light from the light

source at a constant divergent angle; and a diffractive optical element for producing a desired light intensity distribution on a predetermined plane, wherein said diffractive optical element is disposed at or adjacent to a position where light from said emission angle conserving optical unit is collected. --

Please substitute the paragraph beginning at page 6, line 16, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- The emission angle conserving optical unit may comprise a fly's eye lens having small lenses arrayed two-dimensionally. --

Please substitute the paragraph beginning at page 6, line 21, and ending on page 7, line 10, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- In accordance with another aspect of the present invention, there is provided an exposure apparatus, comprising: an illumination optical system for illuminating a mask surface, as a surface to be illuminated, with use of light from a light source, said illumination optical system including (i) an emission angle conserving optical unit effective to emit the light from the light source at a constant divergent angle, and (ii) a diffractive optical element for producing a desired light intensity distribution on a predetermined plane, wherein said diffractive optical element is disposed at or adjacent to a position where light from said emission angle conserving

optical unit is collected; and a projection optical system for projecting a pattern formed on the mask surface, as illuminated with the light from said illumination optical system, onto a wafer. --

Please substitute the paragraph beginning at page 7, line 11, and ending on page 8, line 1, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- In accordance with a further aspect of the present invention, there is provided a device manufacturing method, comprising the steps of: applying a photosensitive material to a wafer; illuminating a mask surface, as a surface to be illuminated, with use of light from an illumination optical system, wherein the illumination optical system includes (i) an emission angle conserving optical unit effective to emit the light from the light source at a constant divergent angle, and (ii) a diffractive optical element for producing a desired light intensity distribution on a predetermined plane, wherein the diffractive optical element is disposed at or adjacent to a position where light from the emission angle conserving optical unit is collected; projecting, through a projection optical system, a pattern formed on the mask surface onto a wafer; and developing the transferred pattern. --

Please substitute the paragraph beginning at page 9, line 17, and ending on page 10, line 7, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- Figure 1 is a schematic view of an illumination system according to an embodiment of the present invention. Denoted in the drawing at 1 is a laser light source, and denoted at 2 is a light directing optical system. Denoted at 3 is a beam shaping optical system, and denoted at 4 and 6 are emission angle conserving optical units. Denoted at 5 is a condensing optical system, and denoted at 7 and 9 are relay optical systems. Denoted at 8 is an aperture stop, and denoted at 10 is a diffractive optical element. Denoted at 11 is a relay optical system, and denoted at 12 is an aperture. Denoted at 13 is a zoom optical system, and denoted at 14 is a multiple-beam producing means. Denoted at 15 is a light projecting means including a condenser lens and the like. Denoted at 16 is a mask or reticle (surface to be illuminated) having a circuit pattern formed thereon. --

Please substitute the paragraph beginning at page 11, line 15, and ending on page 12, line 2, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- Here, as shown in Figure 2A, the emission angle conserving optical unit 4 comprises an aperture 21 and a lens system 22. It has such a property that, even if the optical axis of the incident light shifts slightly as depicted at 27 or 28 in the drawing, the emission angle 29a of the light emitted therefrom is maintained constant. Alternatively, as shown in Figure 2B, the emission angle conserving optical unit 4 may be provided by a fly's eye lens having small lenses. On that occasion, the emission angle 29b of the light is determined by the shape of the fly's eye

lens. With the use of an emission angle conserving optical unit comprising a fly's eye lens such as shown in Figure 2B, the emission angle 29b of the emitted light can be held constant. --

Please substitute the paragraph beginning at page 12, line 19, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- The emission angle conserving optical unit 6 has a similar structure and a similar function as those of the optical unit 4 described above, and the emission angle β of the light emitted therefrom is constant. --

Please substitute the paragraph beginning at page 12, line 24, and ending on page 13, line 20, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- The light emitted from the optical unit 6 at a desired emission angle β is collected by the relay optical systems 7 and 9, and it is directed to the diffractive optical element 10. In this embodiment, the diffractive optical element 10 is disposed at or adjacent to a position which is optically conjugate with the light exit surface of the optical unit 6. With this structure, even if the light from the light source changes slightly, the incidence position and the divergent angle (or convergent angle) of the light entering the diffractive optical element 10 can always be controlled at desired values. As a result, the light intensity distribution to be produced at the surface can always be maintained constant. In Figure 1, the element is disposed at a position slightly deviated from the convergence point P of the light rays emitted from arbitrary points on the light

exit surface of the optical unit 6 (i.e., adjacent to a position optically conjugate with the light exit surface of the optical unit 6), and it is illuminated with incident light having a divergent angle (convergent angle) γ. This will be described in detail, with reference to Figures 3A and 3B. --

Please substitute the paragraph beginning at page 13, line 11, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- The size of each light spot 32a or 32b differs with the relative distance between the diffractive optical element 10 and the convergence point P (i.e., deviation from the conjugate position of the light exit surface of the optical unit 6). By making this relative distance large, as shown in Figure 3B, the size of the light spot 32b may be made large, such that the light spots are superposed one upon another on the diffractive optical element surface 31. By disposing the diffractive optical element 10 adjacent to the conjugate position of the light exit surface of the optical unit 6, as shown in Figure 3B, damage to the element due to the energy concentration upon the diffractive optical element surface 31 can be prevented. The distance from the conjugate position of the light exit surface of the optical unit 6 whereat the diffractive optical element 10 is disposed, may preferably be kept so that a portion of the light spots 32b comes out of the diffractive optical element 10 surface. --

Please substitute the paragraph beginning at page 16, line 22, and ending on page 17, line 3, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- Referring back to Figure 1, the light beam incident on the diffractive optical element 10 is amplitude-modulated or phase-modulated as calculated, and it is diffracted thereby. The light goes through the relay optical system 11, and a desired illuminance distribution 12a (as that of Figures 5A, 5B or 5C) having a substantially uniform intensity within the distribution is produced at the position of the aperture 12. --

Please substitute the paragraph beginning at page 17, line 4, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- Here, the diffractive optical element 10 and the aperture 12 are placed in the relation of Fourier transform planes. Based on this relationship, light diverged from an arbitrary single point on the diffractive optical element 10 contributes to the whole illuminance distribution 12a. Namely, in Figures 3A and 3B, by an arbitrary light beam which forms the light spot 32a or 32b, regardless of its irradiation position, an illuminance distribution 12a (as in Figures 5A - 5C) suitable for the illumination can be produced at the aperture 12 position. --

Please substitute the paragraph beginning at page 17, line 23, and ending on page 18, line 9, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- Next, a description will be made of the magnification change of the zoom optical system 13. A desired illuminance distribution 12a being substantially uniform within the distribution and being formed by the diffractive optical element 10, is projected by the zoom

optical system 13 onto the light entrance surface of the multiple-beam producing optical system 14 at a desired magnification, as a uniform light source image 14a. Here, the term "desired magnification" refers to a magnification which functions to set the size of the uniform light source image so that the incidence angle ζ of the projected light on the surface 16 to be illuminated has a value best suited to the exposure. --

Please substitute the paragraph beginning at page 18, line 10, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- If, with respect to a desired magnification m, the light entrance side NA (numerical aperture) of the zoom optical system 13 as determined by the angle δ is NA′, and the light exit side NA (numerical aperture) of the zoom optical system as determined by the angle ε is NA″, the following relation is obtained:

$$NA' = m \cdot NA'' \qquad \ldots (1)$$

Here, as regards the magnitude of the angle ε, from the standpoint of illumination efficiency, preferably, it should be close, as much as possible to, but not exceeding, the NA with which the light can enter the multiple-beam producing means 14. Therefore, an optimum angle being dependent upon the multiple-beam producing means 14 is set. Thus, as seen from equation (1), once an optimum magnification for the exposure process in a certain condition is determined, the optimum angle of δ is also determined. --

Please substitute the paragraph beginning at page 20, line 19, and ending on page 21, line 5, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- Figure 6A corresponds to a case wherein the incident angle ζa of the light incident on the surface 16 is relatively small (this being called a small σ value). In this embodiment, in order to make the σ value small, the image 14a of the illuminance distribution to be produced by the diffractive optical element 10 on the light entrance surface of the multiple-beam producing means 14 should be imaged at a small magnification. Although this can be accomplished by changing the magnification of the zoom optical system 13, as described hereinbefore, the value ζa is set at an optimum angle dependent upon the entrance side NA of the multiple-beam producing means 14. --

Please substitute the paragraph beginning at page 21, line 6, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- Therefore, as seen from equation (1), once the magnification for attaining a desired σ value is determined, the divergent angle ζa of the light of the illuminance distribution, produced by the diffractive optical element 10 at the position of the aperture 12, is determined fixedly. While the angle δa is determined by the width Da of light incident on the diffractive optical element 10, this width is dependent upon the width 6a of light impinging on the optical unit 6. Thus, the emission angle conserving optical unit is changed to the unit 4a to set a smaller

emission angle αa, thereby to narrow the light flux width 6a. With this procedure, illumination of a high efficiency and with a small angle ζa (small σ value) is accomplished. --

Please substitute the paragraph beginning at page 21, line 21, and ending on page 22, line 9, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- On the other hand, Figure 6B shows an example where the σ value is large. In this case, the emission angle conserving optical unit is changed to the unit 4b having a larger emission angle, to set the large emission angle αb. By this, the width Db of light incident on the diffractive optical element 10 is made large, and the angle δb of light diverged from the illuminance distribution as produced by the diffractive optical element 10 is made large. Even though the image 14b thereof is projected on the multiple-beam producing means 14 at a large magnification, from the relation of equation (1), the angle εb can be set to be substantially the same as the above-described angle εa. With this procedure, illumination of a high efficiency and with a large angle ζb (large σ value) is accomplished. --

Please substitute the paragraph beginning at page 22, line 24, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- As has been described with reference to Figure 2B, for example, even if the light from the laser light source 1 changes slightly due to any external disturbance, the emission angle of the light from the emission angle conserving optical unit 4 is conserved. Therefore, in Figure 1, the

position of the incident light on the optical unit 6 is unchanged. Further, since the emission angle of light from the optical unit 6 is also conserved, there occurs substantially no change in the position of the incident light on the diffractive optical element 10 or in the width of the light there. Thus, when the whole light source image inside the small lenses of the multiple-beam producing means 14 is viewed macroscopically, it can be said that substantially no change has occurred. Consequently, the influence to the illuminance distribution on the surface 9 to be illuminated becomes very small so that it can be disregarded. This clearly suggests the advantages of the present invention that the system is very stable against a change of light from the laser light source. --

Please substitute the paragraph beginning at page 23, line 27, and ending on page 24, line 4, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- (b) Even if there occurs a change in the light in dependence upon the laser light source, the incidence angle of the light incident on the surface to be illuminated is stable. Thus, the adverse effects of the change to the exposure can be removed. --

Please substitute the paragraph beginning at page 24, line 5, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- (c) Use of a diffractive optical element, having a small glass material thickness in place of an optical pipe, ensures an illumination system having a high efficiency even in a vacuum ultraviolet region in which the transmission factor is low. --

Please substitute the paragraph beginning at page 24, line 14, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- Next, a description will be made of an embodiment in which an illumination system of the present invention is applied to an illumination optical system of an exposure apparatus for the manufacture of semiconductor devices such as semiconductor chips (e.g., ICs or LSIs), liquid crystal panels, CCDs, thin film magnetic heads, or micro-machines, for example. --

Please substitute the paragraph beginning at page 24, line 25, and ending on page 25, line 9, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- Denoted in the drawing at 71 is a beam shaping optical system for transforming light from a laser light source 1 into a desired beam shape. Denoted at 72 is an incoherency transforming optical system for transforming a coherent laser beam into incoherent light. Denoted at 73 is a projection optical system, and denoted at 74 is a photosensitive substrate such as a wafer, for example, having a photosensitive material applied thereto. Like numerals as those of Figure 1 are assigned to corresponding elements, and a description thereof is omitted. --

Please substitute the paragraph beginning at page 28, line 12, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- Although in this embodiment the surface 16 is illuminated with a generally uniform illuminance distribution, the emission angle of light emitted from each small region of the multiple-beam producing means 14 may be so set that different angles are defined with respect to two orthogonal directions. On that occasion, the surface 16 can be illuminated with a slit-like shape. --

Please substitute the paragraph beginning at page 28, line 23, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- Figure 8 is a flow chart of the procedure for the manufacture of microdevices such as semiconductor chips (e.g., ICs or LSIs), liquid crystal panels, CCDs, thin film magnetic heads or micro-machines, for example. --

Please substitute the paragraph beginning at page 29, line 1, with the following. A marked-up copy of this paragraph, showing the changes made thereto, is attached in Appendix A.

-- Step 1 is a design process for designing a circuit of a semiconductor device. Step 2 is a process for making a mask on the basis of the circuit pattern design. Step 3 is a process for preparing a wafer by using a material such as silicon. Step 4 is a wafer process (called a pre-process) wherein, by using the so prepared mask and wafer, circuits are practically formed on the wafer through lithography. Step 5 subsequent to this is an assembling step (called a post-